FDI, Technological Regime, and Innovative Effort: Evidence From China

Wei Zhang, Jian Du, Yunlong Zhang[1]

1. Introduction

As one of the basic drives of globalization, Foreign Direct Investment (FDI) is playing an active role in the economic development of NIEs. For instance, in China 2004, fixed assets investment, industry value added, and export of FDI firms accounts for 12%, 28%, and 57% of nation's total amount. 24 million employees are hired by FDI firms which accounts for 10% of all non-agriculture work force. The inflows of FDI not only increase the capital and create employment opportunities but also influence the innovation process of host countries. Through spillover effect of FDI host countries may improve their technological capability, organizational efficiency and management skills and even start endogenous growth.

However, the condition and mechanism of spillover are so complicated that conclusions diverge on how FDI impacts innovative output in host countries. Innovative effort reflects the volume of resources that a company dedicates to carrying out innovative activities over a given period of time. In the area of technological innovation, the relationship between innovative effort and innovation output is validated by a number of studies (Griliches,1990; Hitt et al.,1997; Hagedoorn,Cloodt,2003). Hence investigating the impact of FDI on innovative effort can help to analyze the mechanism of FDI on innovation output and provide profound understanding the role FDI plays in the development of host countries.

The direct relationship between FDI and innovation effort is not difficult to comprehend. Kokko(1994) classifies the routes of FDI spillover into four types, namely linkage effects, competition effects, demonstration effects and training effects. Take competition effect for example. When MNCs enter LDCs and compete for limited market, domestic firms are very likely to be forced to increase R&D input to accelerate the upgrade of technology and equipment.

The property of technology is another crucial factor affecting innovation effort. Nelson and Winter (1977) introduce the notion of technological regime into innovation research and use it as a theoretical framework to analyze and explain

---

[1] School of Management, Zhejiang University, China

innovation process in different industries. Maleba and Orsenigo(1990,1993) develop the concept of technological regime and figure that it comprise technological opportunities, appropriability of innovations, cumulativeness of technical advances and properties of the knowledge base. Based on Maleba and Orsenigo's definition, Park and Lee (2006) add four variables of technological regime for cases of the catching up in developing countries: accessibility to external knowledge flows, relative technological cycle time, initial stock of accumulative knowledge and fluidity /uncertainty of technological trajectory.

The notion of technological regime provides a synthetic way of representing some of the most important economic properties of technologies and of the characteristics of the learning processes that are involved in innovative activities. It identifies structural conditions that contribute to the define competencies, the incentives and the dynamic properties of the innovative process (Breschi, et al., 2000). These fundamental factors may significantly affect innovation effort. For example, technological opportunities are proved to be positively related with innovation effort by a great deal of research (Scherer,1965; Levin et al.,1985; Jaffe,1986,1988,1989; Geroski,1990; Klevorick et al.,1995).

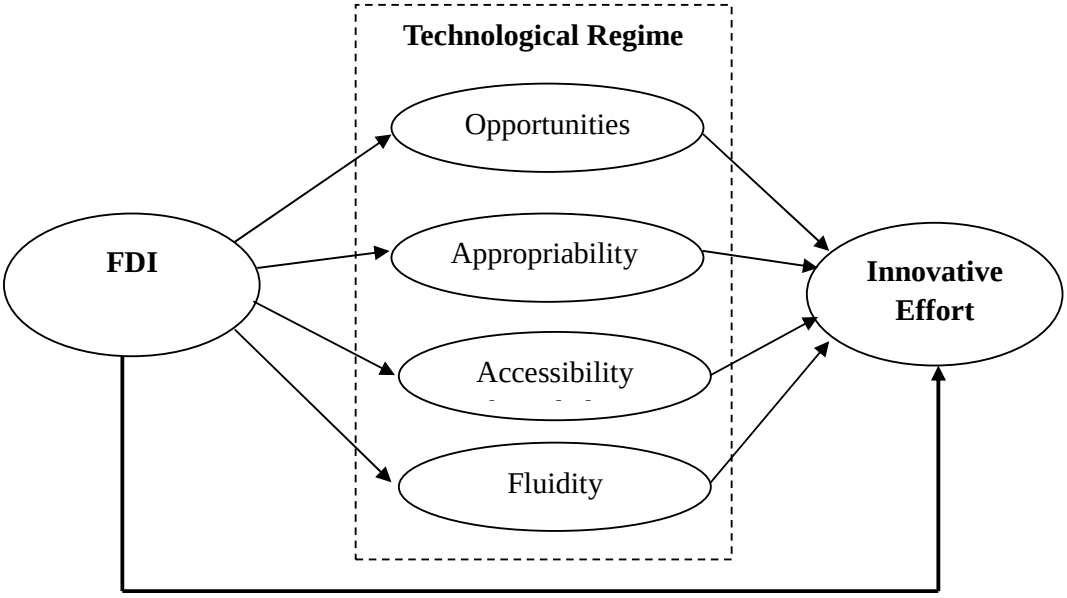
As a sort of innovation source, FDI also impacts technological regime. For instance, the main reason why demonstration effects occur is that the inflow of FDI increases the opportunities of obtaining information and knowledge and enables domestic firms to catch up with MNCs by reverse engineering(Kim,1980; de Melto et al,1980)or secondary innovation (Wu,1995).

This article seeks to shed some light on the impact of FDI on host countries' innovative effort by linking the research on FDI spillover and technological regime. The theoretical model of this paper is shown in Fig.1. The main hypotheses are: (1) FDI inflows are positive related with innovative effort of domestic firms; (2) Technological regime exercises a mediating effect between FDI and innovative effort of domestic firms.

In this model, fundamental factors of technological regime include technological opportunities, appropriability of innovations, accessibility to external knowledge flows, and fluidity of technological trajectory which can be measured mainly by statistical data. We use 28 industries in China from year 1999 to 2003 to test our hypotheses by panel data and regression analysis.

The rest part of this paper is organized as follows: Section 2 considers the characteristics of each variable involved in the model and suggests what relationships would likely exist between them. Section 3 defines the measurements employed to make each of the variables usable and describes the methodology. Section 4 presents the principal results obtained, while Section 5 discusses the possible explanations for results and sums up the main conclusions that may be drawn.

Fig.1
The Theoretical Model



2. Review of the Literature and Drawing up of Hypotheses

2.1 Direct relationship between FDI and innovative effort

Innovative effort reflects the volume of resources that a company dedicates to carrying out innovative activities over a given period of time (Nieto, 2005). How FDI impact on innovative effort can be analyzed through the point of view of FDI spillover. Among four types of spillover identified by Kokko(1994), demonstration effects and competition effects are most likely to result in increase of innovative effort.

Demonstration effects are also called contagion effect (Findlay,1978; Das,1987). Due

to the existence of technology gap, firms in host countries upgrade their technology capability by imitating and assimilating MNC's new technology, product and manufacturing process. To facilitate these learning activities, more efforts are necessarily put into innovation. Demonstration effects cause active increase on effort while competition effects can result in passive response. To compete with MNCs, domestic firms are forced to put more innovative effort and accelerate the upgrade of technology capability.

However FDI spillover does not always lead to increase on innovative effort. Technology spillover caused by entrance of MNCs can be considered as a form of knowledge spillovers and some studies indicate that knowledge spillover may reduce the level of effort put into innovation (Spence, 1984; Bernstein and Nadiri, 1989). The size of this disincentive effect depend on the level and nature of the knowledge spillovers existing in any given technological environment and on the intensity of the competition present among companies. However for the direct relation between FDI and innovative efforts, we still can draw up hypothesis as follows:

Hypothesis 1: Inflows of FDI positively impact on innovative efforts

2.2 Mediate effect of technological regime

2.2.1 Technological opportunities

1. Technological opportunities and innovative effort

Technological opportunities reflect the likelihood of innovating for any given amount of money invested in search or exogenous variations in the cost and difficulty of innovation in different technological areas (Jaffe, 1986). High opportunities provide powerful incentives to the undertaking of innovative activities (Breschi, et al., 2000). Empirical research on how technological opportunities impact on innovative efforts is plentiful. Most research indicate that there is positive relationship between the level of technological opportunities and innovative effort (Scherer,1965; Levin et al.,1985; Jaffe, 1986,1988,1989; Geroski, 1990; Klevorick et al., 1995). Especially, technological opportunities significantly influence on R&D input and ration of new products sale among total amount.

2. FDI and technological opportunities

Blomström (1996) argues that technological opportunities come from decrease of uncertainties. Before launching new products or process, potential adopters have limited understanding about the cost and profit of innovation, thereby considering it a high risk. If potential adopters of innovation contact existing users such subsidiary companies of MNCs, related technical information will diffuse and the uncertainties of supporting or opposing innovation will decline and accordingly the possibility of imitation and adoption will rise. Based on this reasoning, FDI can demonstrate the profitability of new products or process and encourage domestic firms to adopt

innovation. In other words, inflows of FDI can influence innovation activities through the accumulation on technological opportunities.

Hypothesis 2: Inflows of FDI positively impact on innovative efforts via technological opportunities.

2.2.2 Appropriability of innovations

1. Appropriability of innovations and innovative effort

Appropriability of innovations summarizes the possibilities of protecting innovations from imitation and of reaping profits from innovative activities (Breschi, et al., 2000). This notion also reflects the amount of profit from innovation (van Dijk, 2000). As a main factor influencing on firms' innovative activities, appropriability is covered in many theoretical research but somewhat neglected in most empirical studies (Negassi, 2003). Empirical research shows that knowledge spillover will increase if firms have difficulties in protecting their innovation (Spence, 1984). Hence innovators' know-how can be easily used by others under environment with low appropriability. High appropriability can efficiently prevent imitation, guarantee more profit from innovation and therefore encourage firms to put more innovative effort.

2. FDI and ppropriability of innovations

The intensity of appropriability of innovation relies on the level and kind of any given technological environment and spillover, as well as the competitive intensity of the industry. In recent years, especially after China joined WTO, some literatures qualitatively analyze the influence of FDI inflows on China's protections of intellectual property. MNCs from developed countries hold most advanced technological knowledge, patents and licenses. Inflows of FDI and globalization compel Chinese government to establish and improve IP protection environment. Furthermore, the demonstration and competition effects of FDI spillover drive domestic firms to put more effort on protecting their own IP. Therefore, though appropriability of innovation is always considered as the inherent feature of technology, it can be influenced by firms' consciousness and nation's institution and this influence can be enhanced by inflows of FDI.

Hypothesis 3: Inflows of FDI positively impact on innovative efforts via appropriability of innovation.

2.2.3 Accessibility to external knowledge flows

1. Accessibility to external knowledge flows and innovative effort

A steady increase in utilizing external sources to acquire and develop technological capabilities is well documented in the literature (Contractor and Narayanan 1990; Granstrand et al., 1992;Chatterji and Manuel, 1993; Roberts, 1995; MacLachlan 1995; Chatterji, 1996).When firms can access to external knowledge to upgrade

technological capability and obtain profit, they may no longer have strong desire to undertake in-house R&D. Innovations cost plenty of fund and human capital and are risky while resource of any firm is limited. Hence firms are more likely to resort to external knowledge to improve technological capability if it cost less than in-house R&D does.

2. FDI and accessibility to external knowledge flows

Hu and Jaffe (2003) assert that, while it is natural for advanced economies to create most of this knowledge stock, non-advanced economies try to tap into this stock, constrained by the limited channels of knowledge diffusion and their abilities to absorb and adapt new knowledge. Apparently, inflows of FDI provide domestic firms with more external knowledge resource. Linkage and demonstration effects taking place in horizontal and vertical relation with MNCs increase the possibilities of obtaining external knowledge flows.

Hypothesis 4: Inflows of FDI positively impact on innovative efforts via accessibility to external knowledge flows.

2.2.4 Fluidity of technological trajectory

1. Fluidity of technological trajectory and innovative effort

The way technological development or innovation occurs affects firms' selection decision of innovation activity. No matter which kind of strategy firms adopt, leading or following or catching-up, they always wish to foresee the trajectory of technology in the future. Park and Lee (2006) use fluidity of technological trajectory to describe the uncertainty of technological development. Generally speaking, due to the limited resource, firms are more willing to focus on a few select sectors which have low fluidity and risk.

2.FDI and fluidity of technological trajectory

For developing countries, inflows of FDI bring more advanced technology, enlarge the scale of knowledge, increase the choices of possible directions of technology upgrade, and result in more fluid technological trajectory. Moreover, FDI improve technological capability of domestic firms through demonstration, competitive and training effects, make it possible for them to explore more direction of upgrading, and therefore increase the fluidity of technological trajectory indirectly.

Hypothesis 5: Inflows of FDI positively impact on innovative efforts via fluidity of technological trajectory.

3. Methodology and description of the empirical study

3.1 Data

We use data of industries in China from the year 1999 to 2003 to test above hypotheses. According to *Industrial Classification and Codes for National Economic Activities* all industries in China are classified into 41 ones at a two-digital level. We excludes industries which lack data and are adjusted during this period such as “other minerals mining and dressing” and “other manufacturing” and obtain 28 manufacturing industries. Data of FDI are collected from *the yearbook of Chinese Industry* and data which are used to measure technological regime and innovative effort are mainly from *the yearbook of science and technology of China.*

3.2 Measurements of variables

3.2.1 Inflows of FDI (FDI)

In existing literature, proportions of sale, assets, number of employees and industry value added shared by foreign firms to the whole industry are all widely used to measure the level of FDI inflows (Caves, 1974; Globerman, 1979; Blomstrom, 1983; Kokko, 1994; Aitken and Harrison, 1999). For simplicity reasons, we adopt proportion of assets to measure this variable in each industry.

FDI = Assets of foreign firms / Assets of all firms

3.2.2 Technological opportunity (TO)

Most of previous research use indirect ways to measure technological opportunities (Geroski, 1990; Malerba, Orsenigo, 1996). We try to use a more direct means. Since technological opportunities reflect the likelihood or difficulty of innovating for investment, we consider the average number of new product projects per firm as a proper indicator. The reason why we do not choose number of patents is based on the level and features of Chinese firms’ innovation capability. At present, a large part of innovations in Chinese firms are innovation based upon assimilation and imitation of imported technology. Hence, numerous products are emerging but independent innovations and patents are quite limited. Among these 28 industries, some ones only have less than 5 patent applications in one year and the numbers vary very sharply in different years and industries. Therefore we use the numbers of new product projects instead of patents.

TO = Number of new product projects / Number of firms

3.2.3 Appropriability of innovations (AI)

Park and Lee (2006) measure appropriability by the ratio of self-citations received to total citations received. Self-citation is defined as a citing patent assigned by its inventors to the same party as the originating patent. However these data about

self-citation is not available in China statistic yearbooks. Since appropriability can be regarded as the possibility of obtain profit from innovation (Raffaele and Stefano, 1997; van Dijk, 2000) , we use profit margin to measure it. High profit margin indicates that innovators succeed in protecting their new products or process and gain profit in return.

AI = Profits of new products / Profits of products

3.2.4 Accessibility to external knowledge flows (AE)

In Park and Lee's research, accessibility to external knowledge flows are measured by the proportion of citation, where patent held by non-G7 cite patent held by G7, in total citation. However this data in China for each industry is also unavailable. We measure this variable as the ratio of expenditure on import and purchase of domestic technology to total intramural expenditure on technical development. The higher this ratio is, the more external knowledge firms access.

AE = (expenditure on import of technology + expenditure on purchase of domestic technology) / total intramural expenditure on technical development

3.2.5 Fluidity of technological trajectory (FT)

Park and Lee (2006) measure fluidity of technological trajectory of a sector as the coefficient of variation of the annual growth rate of patents in each sector. The coefficient of variation is the standard deviation divided by the mean. This index can be used to measure the technological fluidity during a given period of time while we are trying to measure it for each year in this study. Hence we use absolute value of growth rate of new products to represent the fluidity of technological trajectory of industries in a certain year.

FT = abs (Growth rate of new products)

3.2.6 Innovative effort (IE)

The proportion of R&D expenditure to volume of sales is widely used to measure innovative effort (Nieto, Quevedo, 2005). But in China data of R&D expenditure in each industry is not available before 2003. Therefore we adopt intramural expenditure on technical development instead of R&D expenditure.

IE = Intramural expenditure on technical development / Volume of sales

3.3 Statistical tools

The statistical tool used to test hypotheses in this study is regression analysis with panel data model.

First, we check the direct impact of FDI inflows on innovative effort. Generally speaking, there are three kinds of Panel data model: pooled regression model, variable intercept model (individual-mean corrected regression model), and variable coefficient model (unrestricted model). F test shows that variable intercept model is the appropriate one for this hypothesis. Because we check the hypothesis by using data of all 28 industries, variable intercept model with fixed effect should be chosen. The equation is shown as follows:

$$IE_{it} = \alpha_i + ßFDI_{it} + u_{it} \quad (1)$$

IE_{it} represents innovative effort of all firms and FDI_{it} represents FDI inflows in industry I in year t. α_i is intercept and varies in different industries. u_{it} is random error term.

To test hypotheses about the mediate effect of technological regime in the relationship between FDI and innovative effort is much more complicated. For each factor of technological regime, we set up three equations to work along with equation (1). Take technological opportunities as an example, equations to test hypothesis 2 are:

$$IE_{it} = \alpha_{1i} + ß_1 FDI_{it} + u_{1it} \quad (1)$$

$$TO_{it} = \alpha_{2i} + ß_2 FDI_{it} + u_{2it} \quad (2)$$

$$IE_{it} = \alpha_{3i} + ß_3 TO_{it} + u_{3it} \quad (3)$$

$$IE_{it} = \alpha_{4i} + ß_1' FDI_{it} + ß_3' TO_{it} + u_{4it} \quad (4)$$

According to the method proposed by Baron and Kenny (1986), we examine the significance level of $ß_1$, $ß_2$ and $ß_3$ and compare the change between significance level of $ß_1$ and $ß_1'$, $ß_3$ and $ß_3'$ to judge if TO is the mediate variable between FDI and innovative effort. This procedure is repeated to test other hypotheses about the mediate effects of technological regime, namely from hypothesis 3 to 5.

4. Results

Table 1 shows the results of regression analysis about direct impact of FDI on innovative effort and the mediate effect of technological opportunities.

Table 1
Results of Regression Analysis on FDI, Innovative Effort and Technological Regime (technological opportunities)

Independent variables	1	2	3	4
FDI	-0.028762***	0.443508***		-0.026555***
	(-5.235000)	(3.356064)		(-3.098076)

TO			0.000656*** (3.843752)	0.000428** (2.022531)
Adjusted R-squared	0.856960	0.457492	0.919342	0.852454
Durbin-Watson stat	2.020919	2.648460	2.122099	1.995817

Notes: (1) Under the values for the beta coefficients of regression values of t are given in brackets; (2) ***significant at 1%; ** significant at 5%.

In hypotheses 1, we surmise that inflows of FDI positively impact on innovative efforts. However, the regression indicates opposite result. It is quite difficult to explain this result from theoretical point of view.

We examine the trends of FDI and innovative effort from 1999 to 2003 by calculating the average of these two indexes of 28 industries. Fig.2 shows that the inflow of FDI is steadily increasing during this period and plays a more and more crucial role in China's manufacturing industry. Meanwhile, if innovative effort is measured by the ratio of expenditure on technical development to volume of sale, we can come to the conclusion that firms' input on innovation is unstable on the whole. This index rises to the peak in 2001 and then begins to drop. The ratios in 2003 and in 1999 are almost at the same level. The unexpected result of hypotheses 1 may be partially caused by this trend.

Fig.2
Average percentage of assets held by FDI in 28 industries

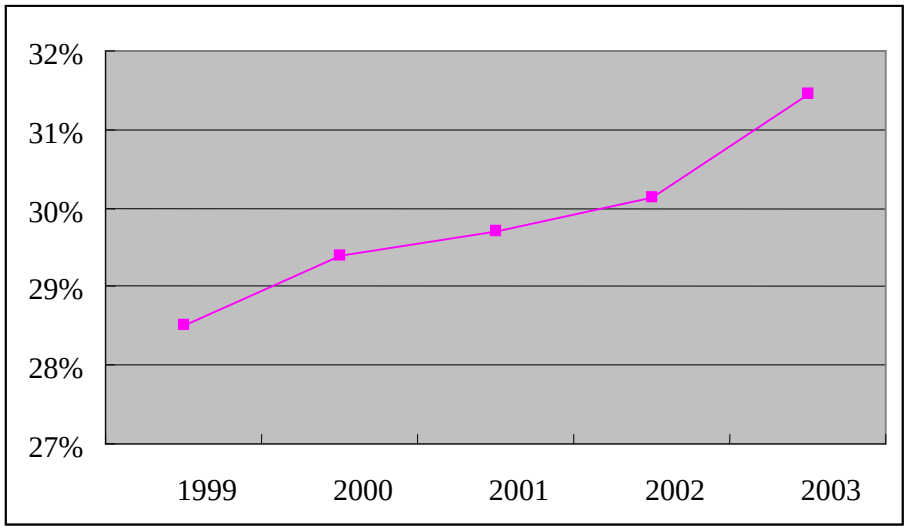


Fig.3
Average of Innovative Effort (Intramural Expenditure on Technical Development / Volume of sales) in 28 Industries

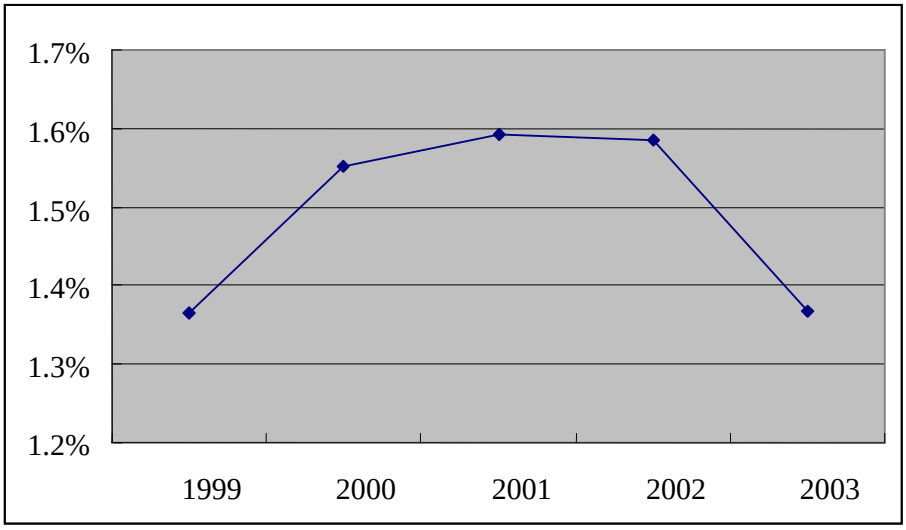


Table.1 also shows that FDI positively influence on technological opportunities at significant level of 1% and technological opportunities has positive impact on innovative effort at significant level of 1% though the coefficient is quite small. When both FDI and technological opportunities are used as independent variables, FDI is still significant related with innovative effort at level of 1% and technological opportunities is significant related with innovative effort innovative effort at level of 5%. In result of equation 4, the absolute value of coefficient of FDI is less than the one in equation 1. Therefore, the negative impact of FDI on innovative effort is reduced by technological opportunities to some extent.

Results of testing other hypothesis are showed in table 2. FDI appears to be positively related with fluidity of technological trajectory and negatively related with appropriability of innovations. Results also indicate that accessibility to external knowledge flows is positively related with innovative effort. However, relationships between FDI and accessibility to external knowledge flows, appropriability of innovations and innovative effort, fluidity of technological trajectory and innovative effort are insignificant. Therefore hypothesis about the mediate effects of these three factors of technological regime between FDI inflows and innovative effort can not be borne out.

Table 2
Results of Regression Analysis on FDI, Innovative Effort and Technological Regime (Appropriability of Innovations, Accessibility to External Knowledge Flows, Fluidity of Technological Trajectory)

Independent variables	2	3	4
FDI	-0.138119*** (-7.615261)		-0.029381*** (-4.817449)

AI		-0.000410	-0.002049*
		(-0.304181)	(-1.780529)
Adjusted R-squared	0.940032	0.922599	0.859024
Durbin-Watson stat	2.144045	2.042610	2.002237
FDI	0.172828		-0.033846***
	(1.357268)		(-8.697612)
AE		-0.000647***	-0.001142***
		(-2.811656)	(-6.436613)
Adjusted R-squared	0.710672	0.906028	0.854317
Durbin-Watson stat	2.297888	2.047121	2.022594
FDI	0.613368***		-0.028490***
	(5.681110)		(-5.481222)
FT		-0.000794	-0.000922*
		(-1.653736)	(-1.685399)
Adjusted R-squared	0.359554	0.919168	0.857977
Durbin-Watson stat	2.350169	2.062958	2.044636

Notes: (1) Under the values for the beta coefficients of regression values of t are given in brackets; (2) ***significant at 1%; ** significant at 5%.

5. Discussion and Conclusions

In section 2, from the point of view of FDI spillover we assume FDI inflows positively influence on innovative effort of firms on the whole. However, regression with panel data of 28 industries in China from 1999 to 2003 shows the opposite result. The unstable and low level of innovative effort of domestic firms may be the main reason. This problem has drawn increasing attentions from scholars and officials.

In the process of globalization, the positive influences of FDI through demonstration, competition or linkage effects on innovative effort only act on a part of domestic firms. On the contrary, numbers of domestic firms reduce input on R&D and begin to rely on technology and products or parts provided by MNCs. For instance, China's TV sets manufacturing industry used to be quite successful in catching-up in the stage of CRT. However, when the technology evolves into the stage of LCD and PDP, MNCs possess the leadership in technology and market, and establish manufacturing braches in China in recent years. To gain short term profit, independent R&D in some domestic firms gives way to purchasing and assembling parts. Therefore, these firms become "assembly workshops" of MNCs. This case may be helpful to explain the drop of innovative effort along with the increasing FDI in some industries.

Statistical analysis in this study also reveals relationships between FDI and some factors of technological regime. FDI inflows are revealed to be positively related with technological opportunities and fluidity of technological trajectory, which is in accordance with our conjecture. Relationship between FDI and accessibility to external knowledge flows is not significant in this regression. A possible reason is that not all accessibility to external knowledge can be precisely measured. Import of technology and purchasing home technology is the main tangible form of technology acquisition. A great deal of knowledge is transferred through R&D cooperation utilizing equity arrangements or non-equity arrangements, as well as other intangible forms such as flows of talent. Contrary to our hypotheses, FDI inflows negatively impact on appropriability of innovations. On the one hand, FDI inflows may be the incentive for domestic firms and government to enhance appropriability system. On the other hand, FDI inflows intensify the competition on innovation and marketing. As the index reflecting the possibility or amount of profit from innovation, appropriability of innovations of certain industry may be reduced by the competition effect of FDI.

Moreover, relationships between factors of technological regime and innovative effort are examined in this paper. Regression analyses show that technological opportunity has significant and positive relation with innovative effort, which is conformable to most previous research. It is also noticeable that accessibility to external knowledge flows has significant and negative relation with innovative effort. Hence our hypotheses about the relationship between these two factors and innovative effort in section 2 are accepted. However influences of appropriability of innovations, fluidity of technological trajectory on innovative effort are not significant in our statistical analyses. At present, appropriability of innovations seems not to be incentive enough to R&D investment. Furthermore, in some fast changing industries such as consumer electronics industry, profit of new products relies more on imitation or improving on appearance instead of investment in R&D. That may explain why the relationship between appropriability of innovations and innovative effort is not significant on the whole. Uncertainty or fluidity of technological trajectory may be a disincentive for some firms to invest in R&D but also can force other firms which have stronger technological capability and adequate resource to simultaneously invest in programs with different standards, technologies or solutions to gain sustainable advantages. Therefore the relationship between fluidity of technological trajectory and innovative effort may be quite difficult to figure out.

Though some relationships between FDI, factors of technological regime and innovative effort are indicated to be significant by regression analyses, the hypotheses about mediate effect can not be borne out. The results show that among every four equations for each factor there is at least one equation with insignificant coefficient. Take appropriability of innovations for example. The relationship between FDI and innovative effort, FDI and appropriability of innovations are significant but the

relationship between appropriability of innovations and innovative effort is not. This result indicates that the mechanism between FDI, technological regime and innovative effort are probably more complicated than the model we draw up. First, more elements, such as other factors of technological regime and strategic factors, should be concerned to synthetically explore impact of FDI on innovative effort. Second, 5 years long period may be too short for study this theme, especially when innovative effort of firms in China appears quite unstable. Using more data in a longer period is one of the topics for further research in the future. In addition, more empirical and theoretical researches are required to analyze and explain the dramatic trends of firms' innovative effort in China which may act as the key to solve this problem.

Acknowledgement

Project 70573092 supported by National Natural Science Foundation of China

References

[1] Aitken, B. and Harrison, A., (1999). Do domestic firms benefit from direct foreign investment? Evidence from Venezuela. *Am. Econ. Rev. 89*, 605–618.

[2] Baron, R., Kenny, D., (1986). The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations, *Journal of Personality and Social Psychology*, Vol. 51, No. 6, 1173-1182

[3] Bernstein, J., Nadiri, M., (1989). Research and development and intraindustry spillovers:an empirical application of dynamic duality. R*eview of Economic Studies* 56, 249–269.

[4] Blomström, M., & Kokko, A, (1996). Multinational Corporations and Spillovers, Working Paper Series in Economics and Finance 99, Stockholm School of Economics.

[5] Blomström, M., Persson, H., (1983). Foreign investment and spillover efficiency in an underdeveloped economy: evidence from the Mexican manufacturing industry. *World Dev*. 11, 493–501.

[6] Breschi, S., Malerba, F., Orsenigo, L. (2000). Technological Regimes and Schumpeterian Patterns of Innovation. *The Economic Journal*, April, vol. 110, no. 463, 388-410(23)

[7] Caves, R.E. (1974), Multinational Firms, Competition and Productivity in Host-Country Markets, *Economica*, Vol. 41, 176-193.

[8] Chatterji, D. (1996). Accessing external sources of technology. *Research-Technology Management* March–April:48–56.

[9] Chatterji, D., and Manuel, T. (1993). Benefitting form external sources of technology. *Research-Technology Management* November–December:21–26.

[10] Contractor, F., and Narayanan, V. (1990). Technology development in the multinational firm:a framework for planning and strategy. *R&D Management* 20(4):305–322.

[11] Das, S. (1987). Externalities, and technology transfer through multinational corporations. *Journal of international economics* 90, 1142-1165.

[12] de Melto, D. et al (1980), Innovation and Technological Change in Five Canadian Industries, Economic Council of Canada, Discussion Paper No. 176.
[13] Findlay, R., (1978). Relative backwardness, direct foreign investment and the transfer of technology: a simple dynamic model. *Q. J. Econ.* 92, 1–16.
[14] Geroski, P., (1990). Innovation, technological opportunity and market structure. *Oxford Economic Papers* 42, 586–602.
[15] Globerman, S. (1979), Foreign Direct Investment and 'Spillover' Efficiency Benefits in Canadian Manufacturing Industries, *Canadian Journal of Economics*, Vol. 12, 42-56.
[16] Granstrand, O., Bohlin, E., Oskarsson, C., Sjoberg, N., (1992). External technology acquisition in large multi-technology corporations. *R&D Management* 22, 111–133.
[17] Griliches, Z., (1990). Patent statistics as economic indicators: a survey. *Journal of Economic Literature* 28, 1661–1707.
[18] Hagedoorn, J., Cloodt, M., (2003). Measuring innovative performance: is there an advantage in using multiple indicators? *Research Policy* 32 , 1365–1379
[19] Hu, A.G.Z and Jaffe, A. (2003), Patent citations and international knowledge flow:the cases of Korea and Taiwan, *International Journal of Industrial Organization* 21
[20] Jaffe, A., (1986). Technological opportunity and spillover of R&D:evidence from firms, patents, profits and market value. *The American Economic Review 76*(15), 984–1001.
[21] Jaffe, A., (1988). Demand and supply influences in R&D intensity and productivity growth. *The Review of Economics and Statistics* 70, 431–437.
[22] Jaffe, A., (1989). Characterizing the technological position of firms with application to quantifying technological opportunity and research spillovers. *Research Policy* 18(2), 87–97.
[23] Kim, Linsu, (1980),Stages of Development of Industrial Technology in a LDC: A Model,*Research Policy*,9,254-277
[24] Klevorick, A.K., Levin, R.C., Nelson, R.R., Winter, S.G., (1995). On the sources and significance of interindustry differences in technological opportunities. *Research Policy* 24, 185–205.
[25] Kokko, A., (1994). Technology, market characteristics, and spillovers. *J. Dev. Econ*. 43,279–293.
[26] Kokko, A., (1994). Technology, market characteristics, and spillovers. *J. Dev. Econ*. 43, 279–293.
[27] Levin, R., Cohen, W., Mowery, D., (1985). R&D appropiability, opportunity and market structure: new evidence on some Schumpeterian hypotheses. *American Economic Review Proceedings* 75(2), 20–24.
[28] MacLachlan, A. (1995). Trusting outsiders to do your research: how does industry learn to do it? *Research-Technology Management* November–December:48–53.
[29] Malerba, F. and Orsenigo, L., (1990). Technological regimes and patterns of innovation: a theoretical and empirical investigation of the Italian case. In *Evolving Technologies and Market Structure*, pp.283-306. Ann Arbor: Michigan

University Press.
[30] Malerba, F. and Orsenigo, L., (1993). Technological regimes and firm behaviour. *Industrial and Corporate Change*, vol.2, no 1, 45-71
[31] Negassi S.2003. R&D co-operation and innovation a microeconometric study on French firms. *Research Policy* 33, 365–384
[32] Nelson, R., and Winter, S, (1977). Dynamic Competition and Technical Progress. In B. Balassa and R. Nelson (eds.), *Economic Progress, Private Values, and Public Policy: Essays in Honor of William Fellner*. Amsterdam: North-Holland.
[33] Nelson, R., Winter, S., (1982). *An evolutionary theory of economic change*, Harvard University Press, Cambridge (MA)
[34] Nietoa, M., Quevedo, P., (2005). Absorptive capacity, technological opportunity, knowledge spillovers, and innovative. *Technovation* 25 (2005) 1141–1157
[35] Paci, R., Usai, S., (1995). Innovative effort, technological regime and market structure in the Italian manufacturing, Working paper version: Contributi di Ricerca CRENoS 95/5.
[36] Park, Kyoo-Ho and Lee, Keun (2006). Linking the technological regime to the technological catch-up: analyzing Korea and Taiwan using the US patent data, *Industrial and Corporate Change*, 15(4):715-753
[37] Roberts, E., (1995). Benchmarking the strategic management of technology-I. *Research-Technology Management,* January–February:44–56.
[38] Scherer, F., (1965). Firm, size, market structure, opportunity, and the output of patented inventions. *American Economic Review* 55,1097–1125.
[39] Spence, A., (1984). Cost reduction, competition and industry performance. *Econometrica* 52, 101–121
[40] van Dijk, M., (2000). Technological regimes and industrial dynamics: The evidence from Dutch manufacturing, *Industrial and Corporate Change*, vol.9,
[41] Wu, Xiaobo, Xu qingrui, 1995, A competitive model of secondary innovation for later-comer's advangtage analysis, *Journal of Industrial Engineering Management* (in Chinese), Vol.9, No.1.